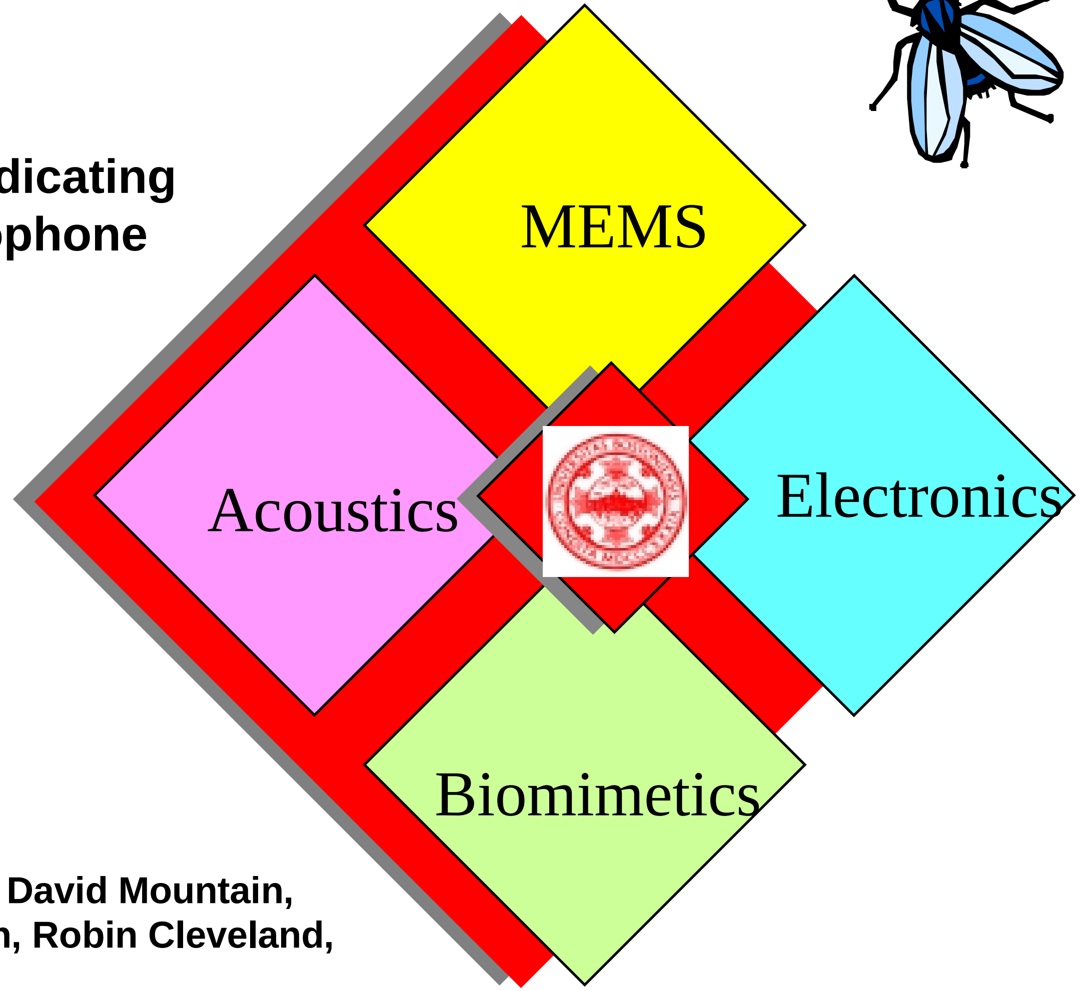
B.U.G.S.: Acoustics



Possibility of a direction-indicating low frequency MEMS microphone

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with acknowledgments to

Debora Compton, Tom Bifano, David Mountain, Allyn Hubbard, Harley Johnson, Robin Cleveland, and others

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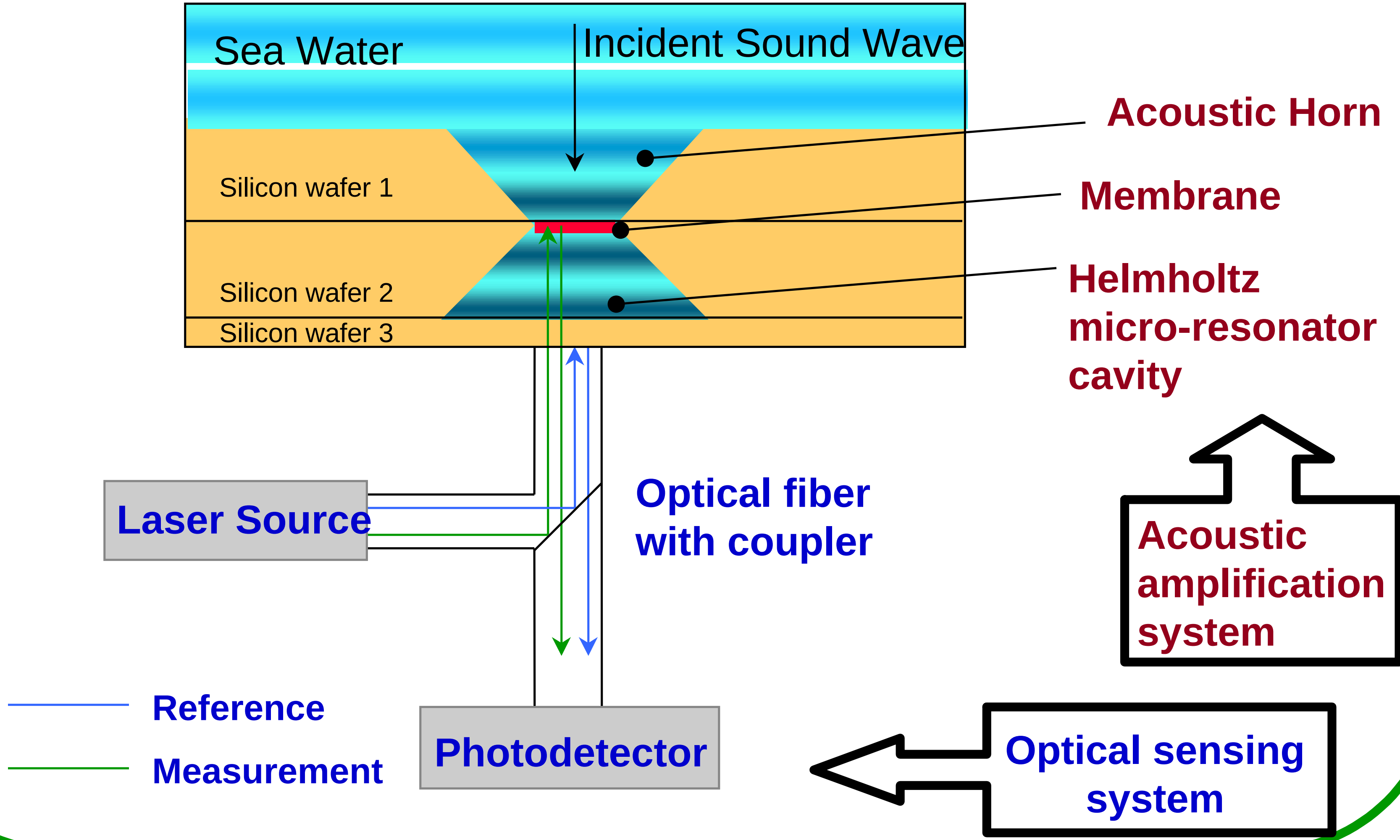
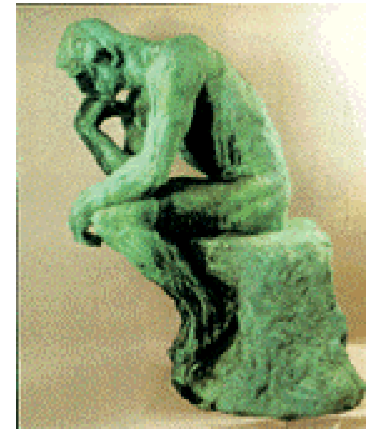
Boston University MEMS Hydrophone (currently under development)

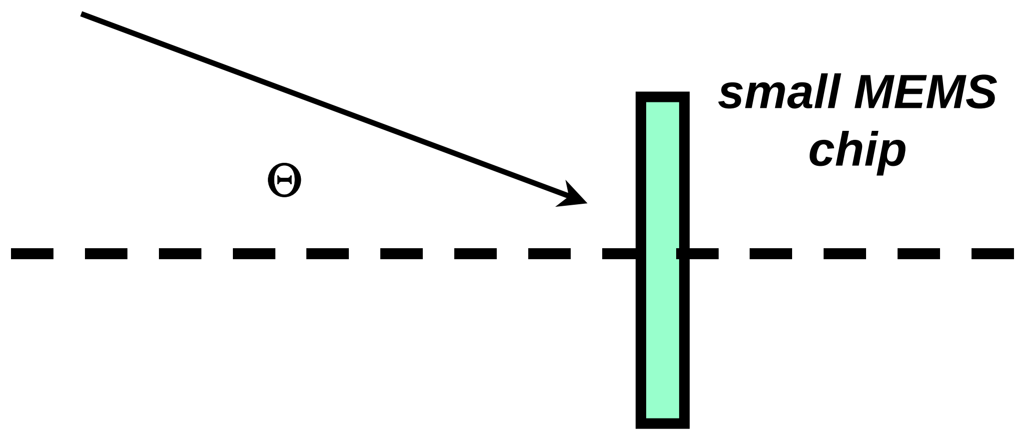


BOSTON UNIVERSITY
GROUP FOR SENSORS

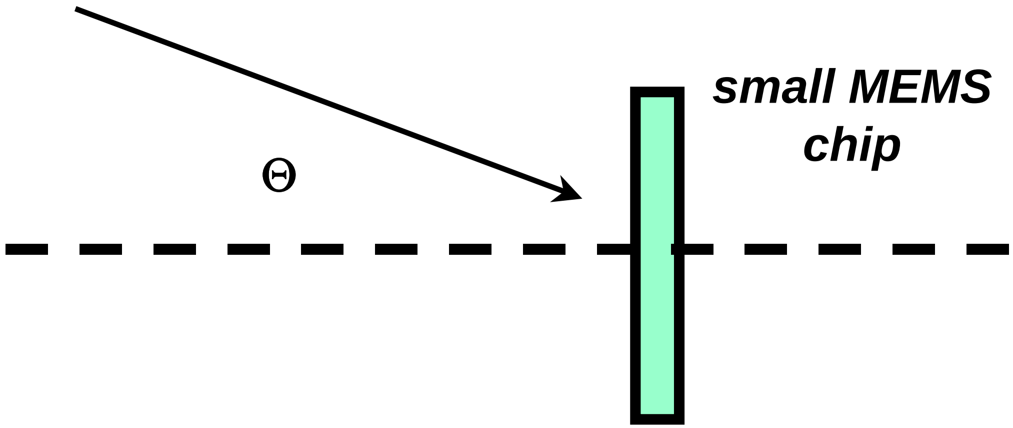
Issue:

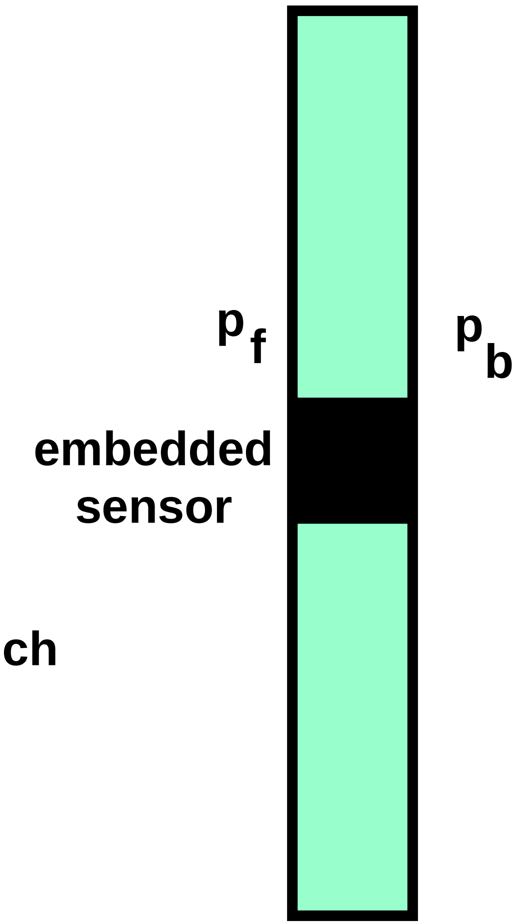
Can we build a compact MEMS device that senses acoustic signals in the lower kilohertz range and which nevertheless gives us a good indication of the direction from which the sound is coming?





What we can do for sure:

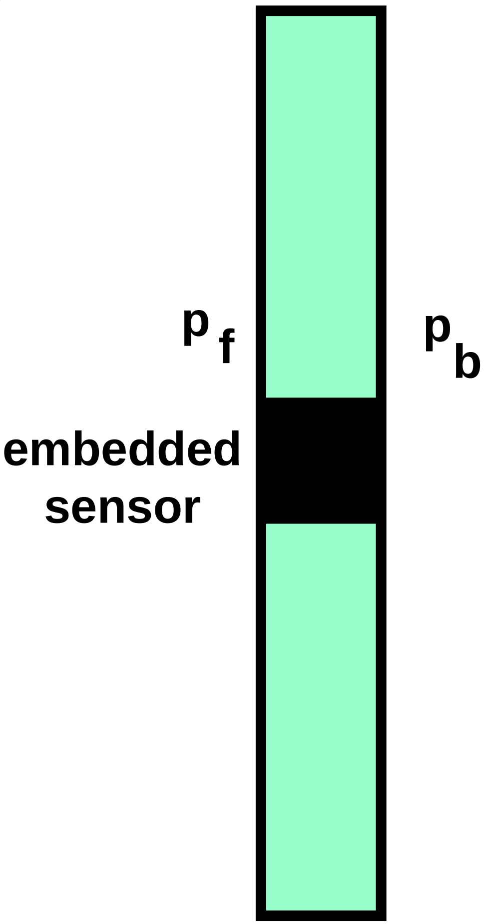




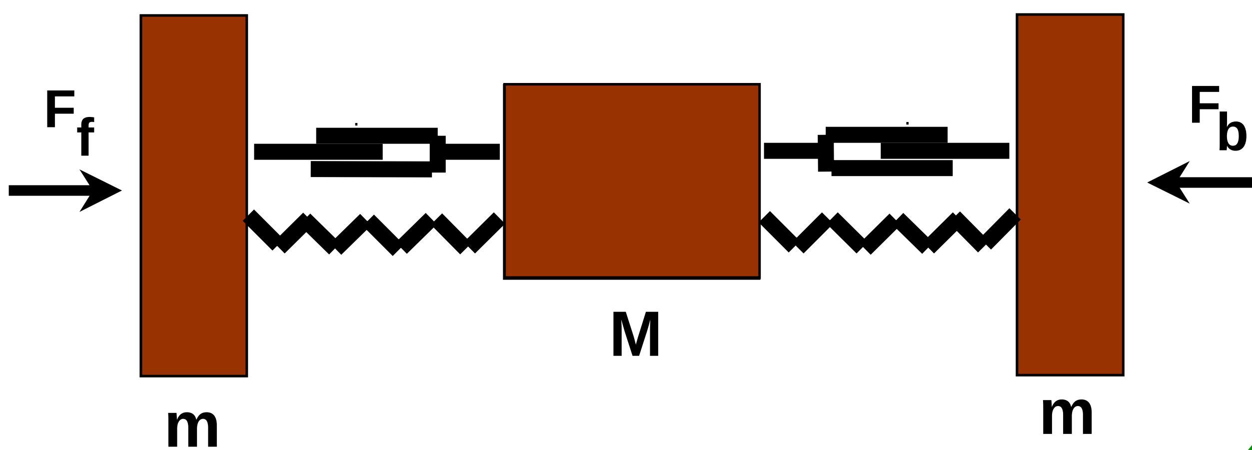
We can design a sensor embedded in the chip which will tell you very reliably *when*

$$\Theta = 0$$

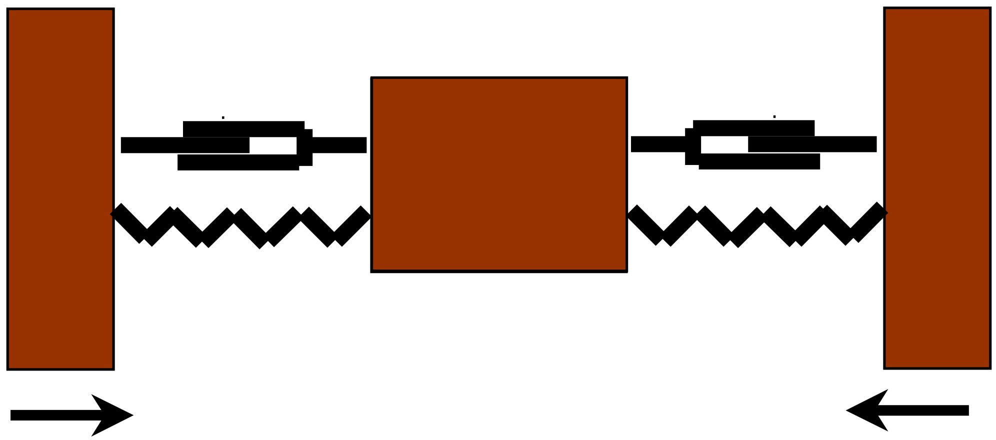
$p_f \approx p_b$, but $p_f \neq p_b$



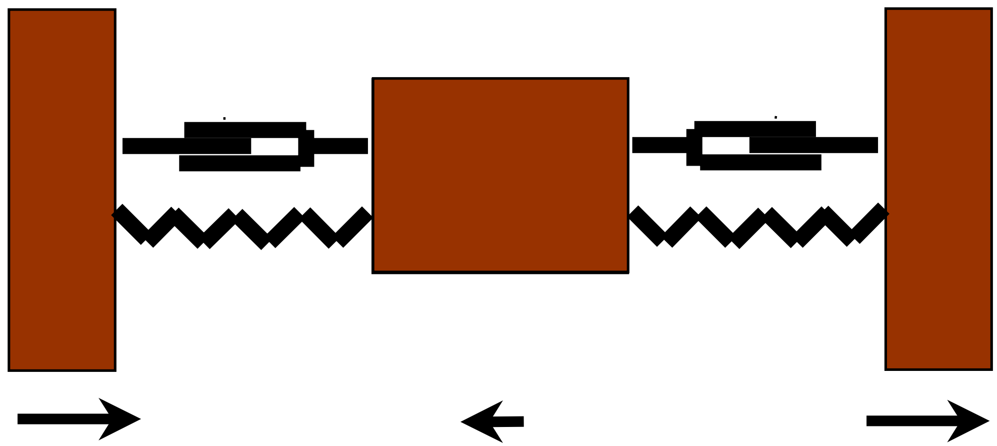
Heuristic mechanical model of the embedded sensor



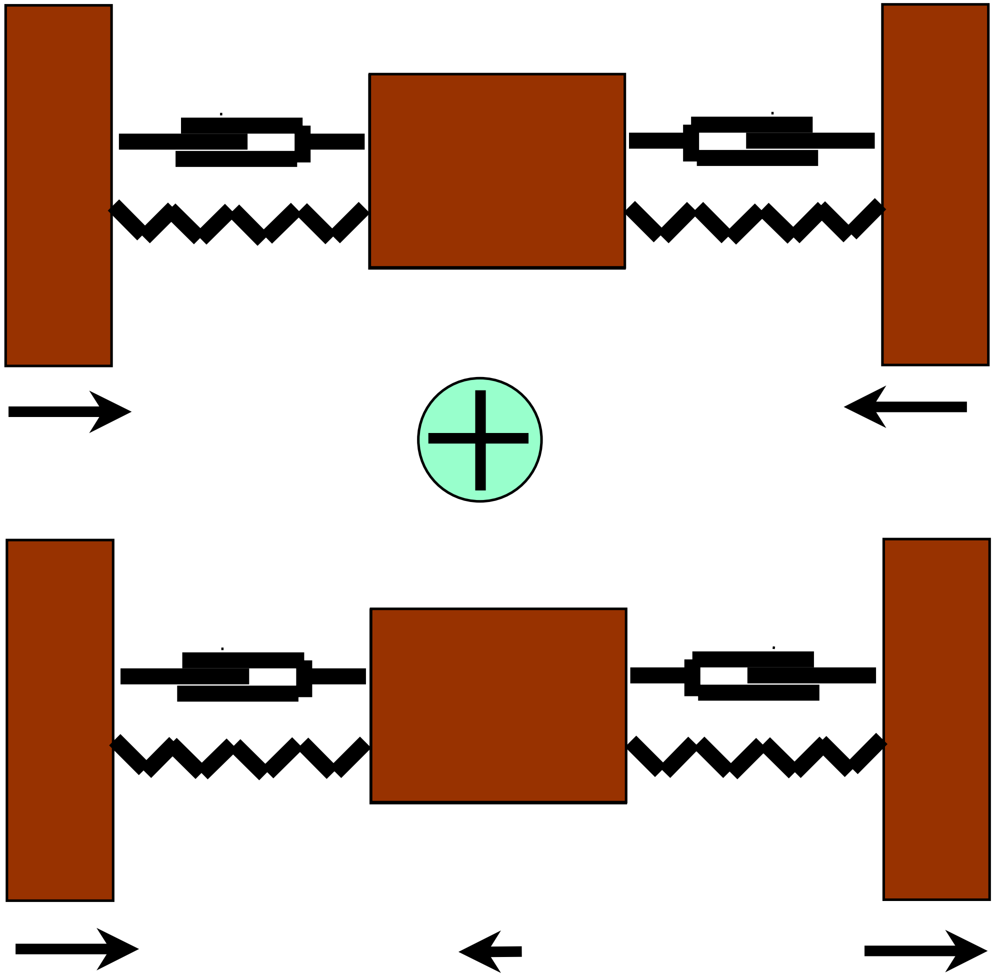
Natural resonance modes



Both faces moving inward (or outward) simultaneously



Both faces moving in the same direction with the same amplitude simultaneously



It is possible to excite the system

so that the relative amplitudes and phases of the two modes

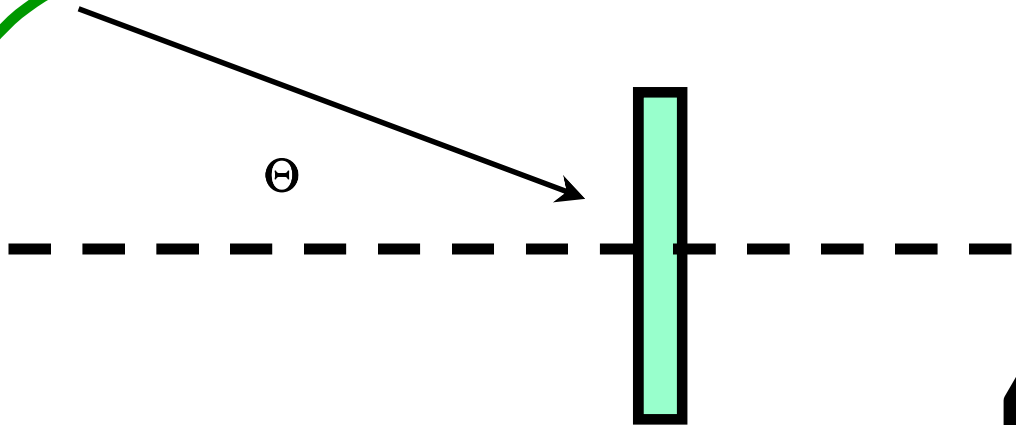
are such that

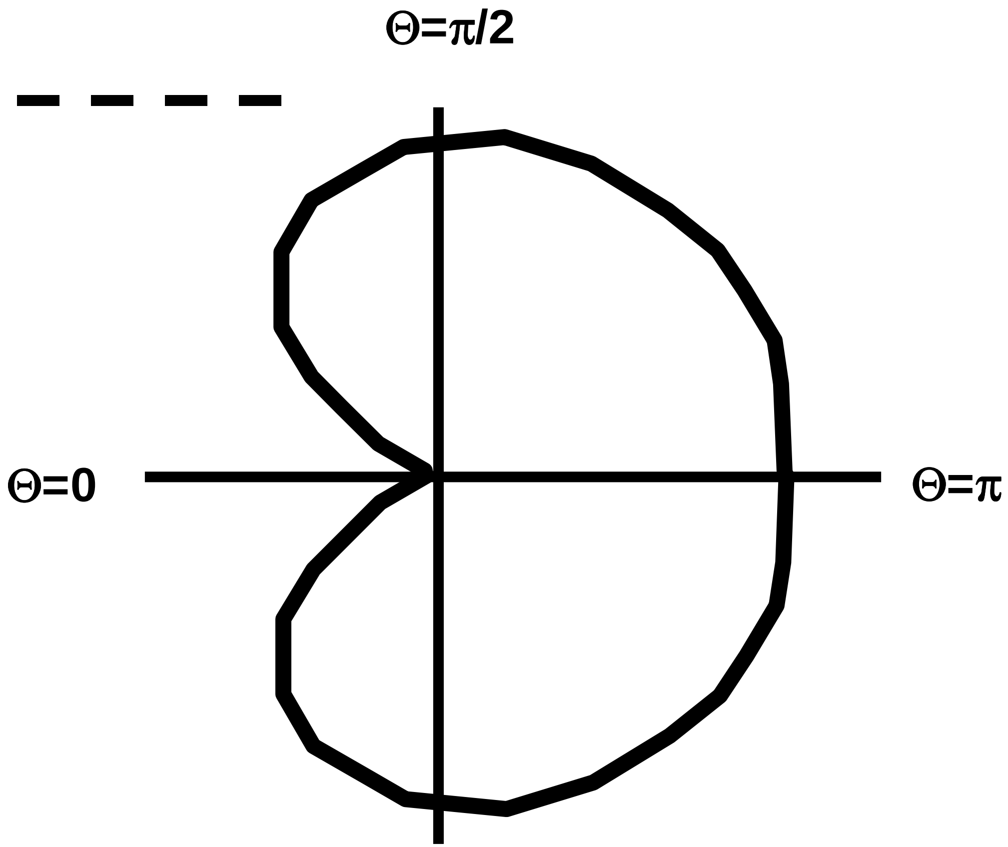
the back face of the sensor

doesn't move at all

Design strategy:

Choose parameters so that this excitation corresponds to Θ=0 for the frequency range of interest





Polar plot:

Radial coordinate corresponds to

vibration amplitude of

back face of

embedded sensor

Comments on possible realizations and extensions

- Frequency range must be close to resonance frequency of non-squeezing mode
- For fixed chip orientation, azimuth direction determination requires array with some minimum lateral distance requirement
- Can design systems with rotatable chips; rotate until $\Theta=0$ is indicated
- Several sensors on same chip possible, each corresponding to a different choice of Θ, different frequency range